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(54) BITUMEN-DEAERATION PROCESS CARRIED OUT IN
THE SEPARATION CELL

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"BITUMEN-DEAERATION PROCESS CARRIED OUT
IN THE SEPARATION CELL"

ABSTRACT OF THE DISCLOSURE

10 The hot water process for extracting bitumen from tar sands is modified to directly produce a deaerated bitumen in the separation cell. Five to sixty parts per million (of the bitumen contained in the tar sand) by weight of a commercial defoamer is added to the tar sands on a conveyor belt as it flows into the conditioning drum. As a result, the froth de-aerates in the separation cell and becomes pumpable by centrifugal pumps without further treatment. Optionally, the defoamer can be added after the conditioning step in the feed to the separation cell or to the froth launder itself as well as to scavenger units which may be employed in the process.

BACKGROUND OF THE INVENTION

This invention relates to the separation of oil from bituminous sands such as Athabasca tar sands. More particularly, the invention relates to a modification to the hot water process for extracting bitumen from tar sands, by which modification de-aerated bitumen is produced directly in the separation cell to obtain froth which is readily pumpable.

In the hot water process employed for recovering oil from tar sands (also known as oil and bituminous sands), such as presently practiced at the Suncor (formerly GCOS) and Syncrude plants in northern Alberta, the tar sands are mulled and jetted with steam together with a minor amount of hot water at temperatures typically from 170°F to 190°F, and the resulting pulp is mixed with hot water and transferred to a separation cell maintained at temperatures from 140°F to 185°F. In the separation cell, sand settles to the bottom as tailings and oil rises to the top in the form of a froth. An aqueous middlings layer comprising clay, silt and some oil is formed between the sand and froth layers. This basic process may be combined with a scavenger step for further treatment of the middlings layer obtained from the primary separation step to recover additional amounts of oil therefrom.

The bituminous froth produced by this process is recovered at a temperature in the range of about 140°F to 180°F and normally has a specific gravity in the range of 0.60 to 0.95 and generally contains about 15-45 wt% air.

In recovering bituminous froth utilizing the process disclosed in Canadian Patent No. 841,581 and the hot water separation cell disclosed in Canadian Patent No. 882,667, the froth is recovered in overflow launders disposed on the upper edge of the extraction cell. Thereafter, the froth flows by gravity into a

collection vessel located near the separation cell below the level of the froth collection launders. Often, one collection vessel serves four or more separation cells to provide a central collection means for recovered froth. Froth from secondary scavenger steps can also be collected in this same vessel. Thereafter, the froth is heated and transferred to a centrifuge zone or to other means for effecting demineralization and dehydration. Normally, the froth is diluted with a liquid hydrocarbon before the demineralization and dehydration steps. Methods for accomplishing water and mineral removal from the froth are disclosed in Canadian Patent No. 910,271 and Canadian Patent No. 918,091.

The bituminous froth, as recovered from the hot water separation cell, resembles a liquid foam with poor flow characteristics. The froth is difficult to pump and therefore must be treated to improve its liquid flow characteristics if it is to be handled by centrifugal pumps. The characteristics of the froth particularly detrimental to handling with centrifugal pumps are: (i) high air content and (ii) high viscosity on the order of 7500 centipoise at 150°F.

Canadian Patent No. 630,710 discloses that bituminous froth can be collected and transferred to a deaeration zone where it is heated with steam at subatmospheric pressures to remove air bubbles from the froth. This end can be accomplished by adding the froth to a steam heated oil bath maintained at subatmospheric pressure. The froth is therein diluted with oil and agitated to remove air bubbles from the froth. Although this method improves the froth, transferring the froth to the treatment apparatus disclosed nevertheless renders the process cumbersome and expensive. Thus, it will be appreciated by those skilled in

the art that it would be highly desirable to provide means for treating bituminous froth directly in the separation cell of the hot water process to obtain improved pumping characteristics.

OBJECTS OF THE INVENTION

It is therefore a broad object of this invention to provide an improved hot water process for extracting bitumen from tar sands.

It is a more particular object of this invention to provide means for deaerating bitumen froth obtained in a hot water process for extracting bitumen from tar sands such that the froth is deaerated and pumpable.

Still more specifically, it is an object of this invention to provide, in a hot water process for extracting bitumen from tar sands, means for deaerating bitumen froth by adding a defoaming agent to the tar sands feed on a conveyor belt as it flows into the conditioning drum. Alternatively, the defoaming agent can be added after the conditioning step in the feed to the separation cell or to the froth launder itself.

DESCRIPTION OF THE DRAWING

The subject matter of the invention is particularly pointed out and distinctly claimed in the concluding portion of the specification. The invention, however, both as to organization and method of operation, may best be understood by reference to the following description taken in conjunction with the accompanying drawing of which the single figure is a simplified schematic representation of a hot water process employing the present invention for extracting bitumen from tar sands.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawing, mined tar sand is fed to the system through line 10 and is carried by a conveyor 9 to a conditioning drum or muller 11. Water is fed to the muller by a line 12, and steam is introduced thereto through line 13. The total water so introduced in liquid and vapor form is a minor amount based on the weight of the tar sands processed and generally is in the range of 10-45° by weight of the mulled mixture. The conditioning drum 11 is provided with suitable kneading or mixing means (not shown) to give the desired mulling action. Enough steam is introduced through line 13 to raise the temperature in the conditioning drum to within the range of 130-210°F and preferably to above 170°F. Mulling of the tar sands produces a pulp which then passes from the conditioning drum as indicated by line 14 to a screen indicated at 15. The purpose of the screen 15 is to remove from the tar sands pulp any debris, rocks, or oversized lumps as indicated generally at 16. The conditioned tar sands passed from the screen 15 to a pulp box 17 which serves as a zone for diluting the pulp with additional water before passage to a primary separation zone 18. Hot water from a heater 27 is passed through line 19 to pulp box 17, and additional steam is fed thereto through line 20 if necessary to maintain the range of 130-210°F and preferably above 170°F. Also, a middlings stream, which is withdrawn from the primary separator 18, may be recycled through lines 21 and 19 to the pulp box. This recycle stream serves to provide sufficient liquid to flood the tar sands pulp from the pulp box and effect transfer of the pulp to the separator. Another function of the recycle stream is to cause dispersion of the pulped material as it is fed into the separation zone 18.

However, such recycling of middlings is not essential in all cases, particularly when the clay content of the tar sands is high. In this event, a relatively high rate of fresh water introduction through heater 27 can be employed to compensate for the high clay content while the correspondingly high rate of transfer of middlings layer through line 26 as hereinafter described can be maintained. Under these circumstances, recycling of the other stream of middlings through lines 21 and 19 to pulp box 17 is not required.

10 Modifications that may be made in the process as above described include sending a minor portion of the middlings recycle stream from line 21 through a suitable line (not shown) to muller 11 to supply all or a part of the water therein other than that supplied through condensation of the steam which is consumed. Also, if desired, a stream of the middlings recycle can be introduced onto the screen 15 to flush the pulp therethrough and into pulp box 17.

20 Separation zone 18 may comprise a large cylindrical or rectangular tank, or battery of tanks, which may, if desired, be provided with heating coils 22 for maintaining a temperature in the range of 130-210°F, and preferably above 170°F. A launder 4 about the upper periphery of a separator collects froth as it floats to the top of the separator and flows over the upper lip thereof. The oil froth is withdrawn via a line 23 from the launder 4 and is transferred under pressure supplied by centrifugal pump 5 for downstream processing (not shown). A sand tailings removal line having a star valve 24 or any other suitable control discharge means is provided at the bottom of the separator 18. Separator 18 also has an intermediate withdrawal line 26 through
30 which a stream of middlings layer is removed in addition to that recycled through line 21.

In operation of the process, the pulped tar sands are continuously flushed from pulp box 17 through line 25 into separator 18 by means of the relatively large flow of water supplied by the middlings recycle stream and the fresh water from heater 27. The settling zone in separator 18 is relatively quiescent so that oil froth rises to the top and sand settles to the bottom. The froth results by virtue of air or gas being trapped in the oil sands during the previous conditioning operation and thus imparts to the oil phase an effective density considerably below that of water. The separation zone 18 should have a horizontal cross sectional area such that there are from 0.1 to 10 square feet of cross-sectional area per ton of virgin tar sands per hour that passes through the screen 15 (calculated on a dry basis). More preferably, such areas should be in the range of 0.5-3.0. Further, the volume of the separation zone should be such that the average retention time of the pulped tar sands charged will be 1-60 minutes, more preferably 2-20 minutes.

Because of the high air content in the froth which flows into the launder 20, the froth is difficult to pump and it has been the practice to submit the froth to a separate deaerating step to render it pumpable. However, it has now been found that froth may be deaerated in the separation cell 18 by the selective addition to the hot water process of a defoaming agent. Specifically, it has been discovered that the addition of 5-60 ppm (calculated as ppm in the bitumen contained in the tar sand) by weight of a defoaming agent (such as Dow Corning Silicone 200) to the tar sands feed on the conveyor belt 9 as it flows into the conditioning drum 11 causes the froth to deaerate in the separation zone 18 and to become readily pumpable by the centrifugal pumps, such as the pump 5, without further treatment. As a specific example, addition of 60 ppm of the Dow Corning Silicone 200 fluid

to tar sands feed at 1800 tons per hour changed the specific gravity of the bitumen froth produced from about 0.65 to about 1.08 at a temperature of 150°F. Concurrently, the viscosity dropped from about 7500 centipoise to about 4000 centipoise (measured on a Brookfield Viscometer Model LVT 4).

Addition of the foaming agent can also be made as indicated at 2 after the conditioning step in the feed to the separation cell or to the froth launder itself as indicated at 3.

10 The middlings layer obtained in separation zone 18 will contain most of the silt and clay which was present in the tar sands in their natural state. In order to prevent the build up of clay in the system it is necessary to continually discard some of the middlings layer and supply enough water in the conditioning operations to compensate for that so discarded. The rate at which the middlings needs to be removed from the system depends upon the content of clay and silt present in the tar sands feed, and this will vary from time to time as the content of these fines varies. If the clay and silt content is allowed to build up in
20 the system, both the density and the viscosity of the middlings layer will increase. Concurrently, with such increase, an increase in the proportions of both the oil and the sand retained by the middlings will occur. If the clay and silt content is allowed to build up too high in the system, effective separation will no longer occur, and the process will become inoperative. Hence, it is important to regulate the withdrawal of middlings through line 26, and the addition of fresh water to the system to compensate for water thus removed, in a way that will keep the separation step operating properly. However, even when this
30 separation step is operating in an optimum manner, the middlings

layer withdrawn through line 26 will contain a substantial amount of oil which did not separate. Hence, the middlings layer withdrawn through line 26 is, for purpose of description, herein referred to as "oil-rich middlings."

The rate of addition of fresh water to the system and the rate of removal of middlings layer from separation zone 18 through line 26 are regulated in accordance with either the density or the viscosity of the middlings layer or both. When density is used for the control, such addition and removal are carried out so that the middlings density is maintained in the range of 1.03-1.50 gm/cc, more preferably 1.10 to 1.20 gm/cc. It is preferred, however, to utilize viscosity to effect the control, in which case the water addition and removal are carried out to maintain the middlings viscosity in the range of 0.5 to 10 centipoise, more preferably 0.6 to 3.0 centipoise. Periodic or continuous measurements of either viscosity or density for the middlings phase can be made, and the removal of middlings through line 26 and corresponding addition of fresh water to the system can be regulated in accordance with the measured values to maintain the value within the range desired. Whenever either density or viscosity tends to become higher than is desired, an increase is made in the rate of middlings removal and corresponding rate of fresh water addition; and if density or viscosity values tend to become too low, decreases in these removal rates are effected.

As a general rule the total amount of water added to the natural bituminous sands as liquid water and as steam prior to the separation step should be in the range of 0.2-3.0 lbs./lb. of the bituminous sands. The amount of water needed within this range increases as the silt and clay content of the bituminous sands increases. For example, when 15% by weight of the mineral matter

of the tar sands has a particle size below 44 microns, the fresh water added generally can be about 0.3-0.5 lbs./lb. of tar sands. On the other hand when 30% of the mineral matter is below 44 microns diameter, generally 0.7-1.0 lb. of water should be used per pound of tar sands. Correspondingly the amount of oil-rich middlings removed through line 26 will vary depending upon the rate of fresh water addition. As a general rule the rate of withdrawal of oil-rich middlings through scavenger zone 29 will be 10-75 gallons per ton of tar sands processed when 15% by weight of the mineral matter is below 44 microns and 150-250 gallons per ton when from 25-30% of the minerals is of this fine particle size.

As previously mentioned, the middlings layer withdrawn through line 26 will still contain a substantial amount of oil even though the separation step is operated under optimum conditions. The amount of oil remaining in the middlings layer appears to be more or less related to the percentage of clay and/or silt present in the tar sands being processed, varying directly with the amount of clay and/or silt present. For example, typical oil recovery values for the froth from tar sands in which 15% of the mineral matter is less than 44 microns and from sands in which 25-30% is less than this size are, respectively, 85% and 60%. For commercial operation, it is highly desirable to obtain increased recoveries over such values as these which are obtainable heretofore by the hot water process. This is particularly true when the tar sands mined contain a relatively high proportion of clay and silt components.

To carry out such secondary recovery, the oil-rich middlings stream withdrawn from separator 18 through line 26 is sent to a scavenger zone 29 wherein an air flotation operation is conducted.

In a large size commercial operation, an increase of oil recovery of even a few percentage values can amount to a large volume of additional oil per day. The processing conducted in scavenger zone 29 provides a controlled zone of aeration in the flotation cell at a locus where agitation of the middlings is being effected so that air becomes dispersed in the middlings in the form of small bubbles. The drawing illustrates a flotation cell of the subaeration type wherein a motorized rotary agitator 30 is provided and air is fed thereto in controlled amount as by means of line 31. Alternatively, the air can be sucked in through the shaft of the rotor. The rotor effects dispersion of the air in the middlings. This air causes the formation of additional oil froth which passes from the scavenger zone 29 through line 32 and thence to line 23 for further processing in admixture with the froth derived from the primary separation in zone 18. The residence time in scavenger cell 29 can vary widely but generally is in the range of 1-60 minutes and usually 2-20 minutes. An oil-lean middlings stream is removed from the bottom of scavenger zone 29 via line 33 and is discarded from the process. The oil-lean middlings contains a substantial proportion of the clay and silt components that were present in the original tar sands, and discarding thereof from the process prevents the build up of this fines material in the separation zone 18. The amount so discarded is such as to maintain the viscosity and density of the oil-rich middlings in zone 18 within the ranges as specified hereinbefore.

It has been found that employment of a defoaming agent as described above obviates, in some cases, the need for carrying out incremental secondary recovery of froth as by the air flotation process just described. If secondary recovery is employed, however, the addition of a defoaming agent, as at 34, renders the froth recovered thereby much more readily pumpable.

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The mixed froths from lines 23 and 32 will contain some water and an appreciable amount of the finer mineral matter that was present in the tar sands. Generally this material will be sent to a processing zone (not shown) wherein the water and mineral matter are removed. This can be achieved by diluting the froth with naphtha and treating the mixture in an electrostatic precipitator or in centrifuges to effect dehydration and demineralization.

10 For securing optimum results with the process as above described, an alkali metal-containing alkaline reagent generally should be added to the conditioning drum usually in the amount of from 0.1 to 3.0 lbs. per ton of tar sand. The amount of such alkaline reagent preferably is regulated to maintain the pH of the middlings layer in separator zone 18 within the range of 7.5-9.0. Best results seem to be obtained at a pH value of 8.0-8.5. The amount of the alkaline reagent that needs to be added to maintain a pH value in the range of 7.5-9.0 may vary from time to time as the composition of the tar sands obtained from the mine site varies. The best alkaline reagents to use for this purpose are caustic
20 soda, sodium carbonate or sodium silicate, although any of the other alkali metal-containing alkaline reagents can be used if desired.

While the principles of the invention have now been made clear in an illustrative embodiment, there will be immediately obvious to those skilled in the art many modifications of structure, arrangements, proportions, the elements, materials, and components, used in the practice of the invention which are particularly adapted for specific environments and operating requirements without departing from those principles.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOW:

1. A process for separating oil from bituminous sands which comprises the steps of:

- A) adding a defoaming agent to the bituminous sands in an amount in the range of 5-60 parts per-million by weight of the bitumen contained in the tar sands feed;
- B) forming a mixture of the bituminous sands and water;
- C) settling the mixture in a separation zone in a temperature range of 130°F to 210°F to form: an upper froth layer; a middlings layer comprising water, clay, and oil; and a sand tailings layer; and
- D) separately removing from the separation zone the oil froth layer and the sand tailings layer.

2. A process for separating oil from bituminous sands which comprises the steps of:

- A) forming a mixture of the bituminous sands and water;
- B) settling the mixture in a separation zone in a temperature range of 130°F to 210°F to form: an upper froth layer; a middlings layer comprising water, clay, and oil; and a sand tailings layer;
- C) separately removing from the separation zone the oil froth layer and the sand tailings layer; and
- D) adding a defoaming agent to the froth in an amount in the range of 5-60 parts per-million by weight of the bitumen contained in the tar sands feed.

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3. A process for separating oil from bituminous sands which comprises the steps of:

- A) forming a mixture of the bituminous sands and water;
- B) adding a defoaming agent to the mixture in an amount in the range of 5-60 parts per-million by weight of the bitumen contained in the tar sands feed;
- C) settling the mixture in a separation zone in a temperature range of 130°F to 210°F to form: an upper froth layer; a middlings layer comprising, water, clay, and oil; and sand tailings layer; and
- D) separately removing from the separation zone the oil froth layer and the sand tailings layer.

4. In a hot water process which includes the steps of:
forming a mixture of the bituminous sands and water; passing the mixture into a separation zone; settling the mixture in the separation zone in the range of 130°F to 210°F to form: an upper froth layer, a middlings layer containing water, clay, and oil, and a sand tailings layer; and separately removing from the separation zone the oil froth layer and the sand tailings layer; the improvement in which a defoaming agent is added to the mixture of bituminous sands and water in an amount in the range of 5-60 parts per-million by weight of the bitumen contained in the tar sands feed.

5. In a hot water process which includes the steps of:
forming a mixture of the bituminous sands and water; passing the mixture into a separation zone; settling the mixture in the separation zone in the range of 130°F to 210°F to form: an upper froth layer, a middlings layer containing water, clay, and oil, and a sand tailings layer; and

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separately removing from the separation zone the oil froth layer and the sand tailings layer; the improvement in which a defoaming agent is added to the froth in the amount in the range of 5-60 parts per-million by weight of the bitumen contained in the tar sands feed.

6. The process of Claims 1, 2, or 3 in which a scavenger step is employed to obtain incremental oil recovery from the middlings layer and in which a defoaming agent is added to froth during the scavenger step.

7. The process of Claims 4 or 5 in which a scavenger step is employed to obtain incremental oil recovery from the middlings layer and in which a defoaming agent is added to froth during the scavenger step.

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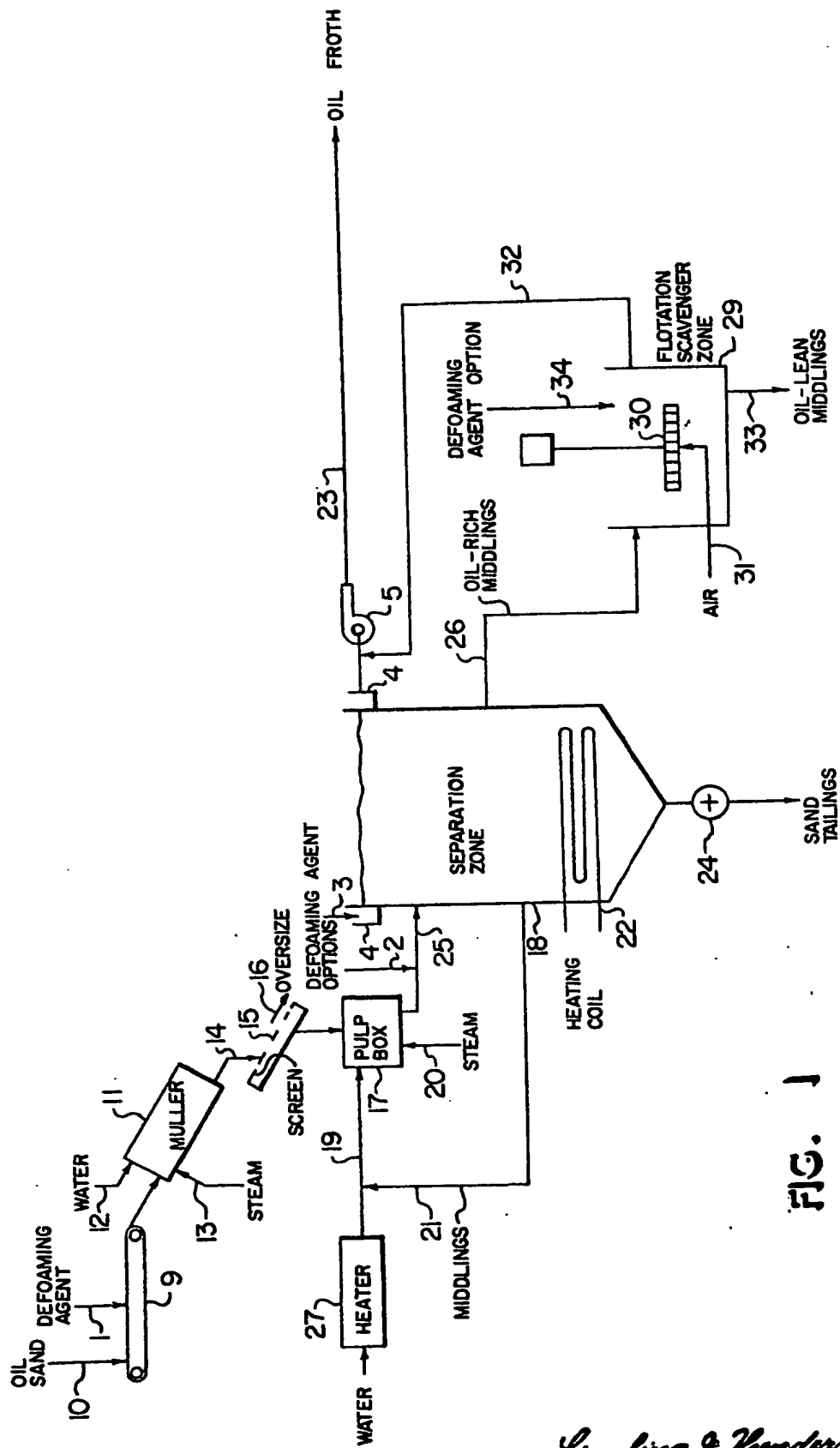


FIG. 1

Cowling & Henderson